The Ordovician–Silurian boundary beds of the north-east USSR

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Synopsis

Graptolites of the *supernus*, *extraordinarius*, *persculptus*, *acuminatus* and *ascensus* Zones are present in sections in the north-east USSR, with the best section at Mirny Creek. Brachiopod and coral faunas also occur with the *Tcherskidium* and *Holorhynchus* beds in the *supernus* Zone and the *Hirnantia*? beds present in the *persculptus* Zone, both within the Tirekhtyakh Horizon. The succeeding *acuminatus* and *ascensus* Zone graptolites are developed in the Chalmak Horizon, which also bears a sparse shelly fauna.

Introduction

The late Ordovician and early Silurian boundary beds in the north-east USSR crop out on the Omulev Uplift in the upper Kolyma Basin. They are built up by terrigenous-carbonate and terrigenous deposits which are variable in composition and contain a mixed shelly-graptolite fauna. The rocks are exposed on limbs of extensive anticlines and show either a monoclinal succession, such as at Mirny Creek, Neznakomka River and Drevnyaya River, or represent large fragments of sections among complex faulted sequences, such as at the Ina River. The Upper Ashgill and Lower Llandovery deposits include the *supernus*, *extraordinarius*, *persculptus*, *acuminatus* and *ascensus* graptolite Zones and have a total thickness of about 300 m (Fig. 1). This part of the section is designated the Tirekhtyakh and Chalmak horizons. The lower part of the Tirekhtyakh horizon (the *supernus* Zone) (Fig. 2) shows a diversity of facies from deep water shales yielding graptolites, for example at Khekandya River and Lukavy Creek, to biohermal and biogenic–detrital carbonates with mixed brachiopod–coral–graptolite faunas as at Mirny Creek and the Ina and Neznakomka rivers. The upper part of the Tirekhtyakh horizon (the *extraordinarius* and *persculptus* Zones) and the lower part of the Chalmak horizon (the *acuminatus* and *ascensus* Zones) are represented by sequences more

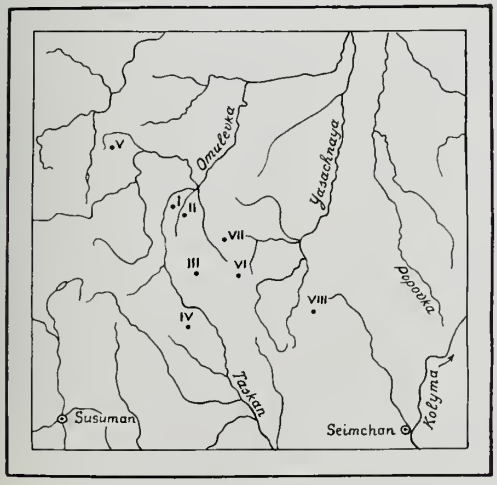

Fig. 1 Distribution of Ordovician–Silurian boundary beds on the Omulev Uplift. I, Mirny Creek; II, Ina River; III, Neznakomka River Basin; IV, Tirekhtyakh River Basin; V, Mount Kharkindzha; VI, Levaya Khekandya River; VII, Drevnyaya River; VIII, Lukavy Creek.

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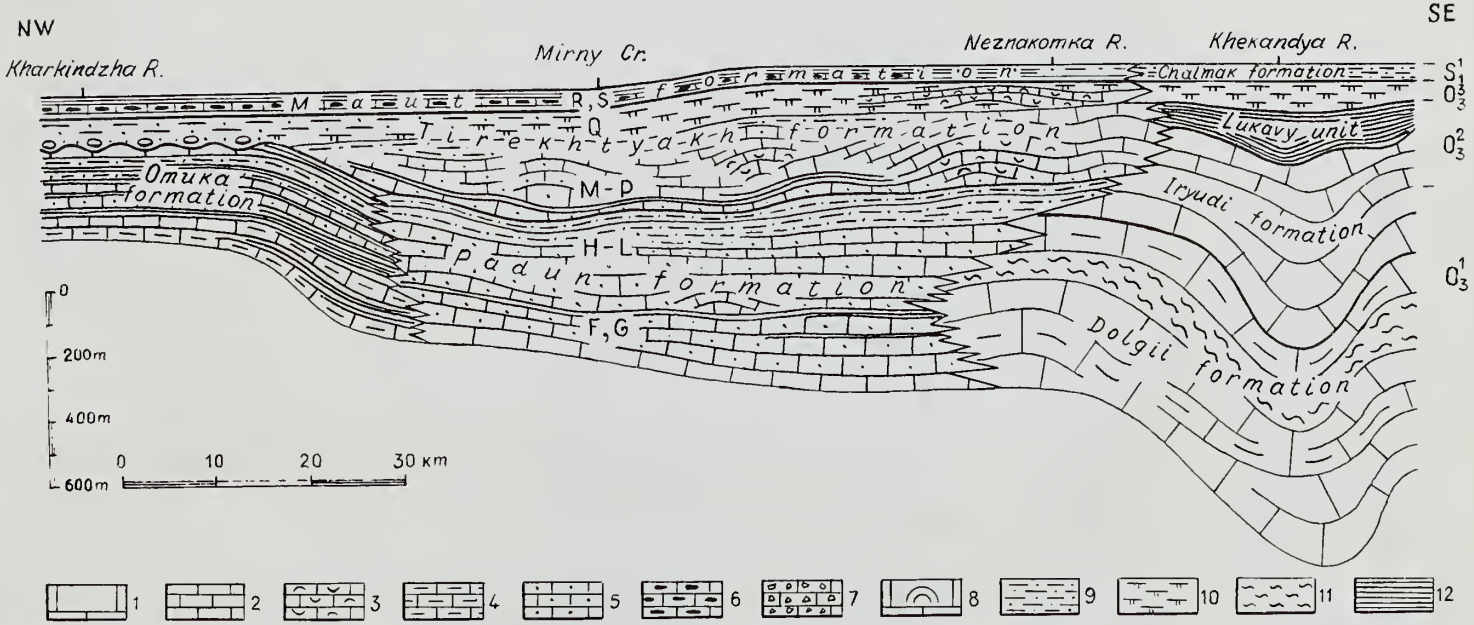

Fig. 2 Lithofacies profile of the Ordovician–Silurian boundary beds on the Omulev Uplift. 1, pelitomorphic massive limestone; 2, pelitomorphic tabular limestone; 3, bioclastic limestone; 4, clayey limestone; 5, silty limestone; 6, siliceous limestone; 7, brecciated limestone; 8, bioherms; 9, calcareous siltstone; 10, dolomitic marl; 11, marl; 12, calcareous shale.

diverse in composition. The Upper Tirekhyakh deposits consist mainly of dolomites, marls, and siltstones representing the termination of the late Ordovician regressive cycle and the Chalmak dark carbonate clay sequences mark the beginning of the Llandovery transgression.

Of greatest interest is the key section at Mirny Creek, which has the best exposed Ordovician–Silurian boundary deposits. This has been studied in detail, and forms a type section for such regional units as formations and horizons.

The Tirekhtyakh horizon

At the Mirny Creek and Ina River sections the horizon is 250 m thick and represented by a formation of the same name (upper unit M to unit Q) which is composed of bedded and massive limestones with tabulate corals, brachiopods, ostracodes and gastropods. The limestones are interbedded with siltstones yielding graptolites. In the Neznakomka River the formation is 315 m thick and represented mainly by biohermal and biogenic-clastic limestones interbedded with siltstones. The rocks contain chiefly brachiopods but the siltstones yield rare graptolites.

In the south-eastern Omulev Mountains (Khekandya River, Yasachnaya Basin, Lukavy Creek and Drevnyaya River) the Tirekhtykh horizon exhibits changes in composition. Its lower part consists of the Iryudi Formation (500–600 m) and Lukavaya sequence (100 m). The Iryudi Formation is composed of clay and pelitomorphic, unevenly bedded limestones with abundant corals and brachiopods. The Lukavaya unit is represented by dark platey limestones intercalated with calcareous shales containing abundant graptolites and rare brachiopods. As at Mirny Creek, the upper part of the horizon includes siltstones.

The Terekhtyakh horizon has been subdivided by means of graptolites in sections at Mirny and Lukavy creeks, the Khekandya and Drevnyaya rivers, and at Mount Kharkindza, and by means of brachiopods mainly in Mirny Creek and the Neznakomka River (Fig. 3). The lower part of the horizon is equated with the *Climacograptus longispinus supernus* Zone and the *Tcherskidium unicum* beds. The *supernus* Zone is subdivided into two subzones, the lower *Climacograptus longispinus longispinus* Subzone and the upper *Paraorthograptus pacificus* Subzone. The lower subzone contains *Climacograptus longispinus longispinus* Hall, *C. l. supernus* Elles & Wood, *C. hastatus* Hall, *C. trifidus spectabilis* Koren & Sobolevskaya, and *Dicellograptus complanatus* Lapworth, whose appearance marks its lower boundary. The *pacificus* Subzone is recognized as a taxon biozone and, along with *Dicellograptus ornatus ornatus* Elles & Wood and subspecies of *Climacograptus longispinus*, contains *Climacograptus latus hekandaensis* Koren & Sobolevskaya and *C. pogrebovi* Koren & Sobolevskaya, while the upper part yields *Glyptograptus*? *ojsuensis* Koren & Mikhailova, *Climacograptus angustus* (Perner), *C. normalis* Lapworth and others.

The *supernus* Zone is equated with the *Tcherskidium unicum* beds which also contain *Ptychoglyptus bellarugosus* Cooper, *Holorhynchus* ex gr. *giganteus* Kiaer and *Eostropheodonta hirnantensis lucavica* Oradovskaya. There are also abundant corals of the genera *Agetolites*, *Heliolites*, *Propora*, *Calapoecia*, *Coxia* and others (Preobrazhensky 1966). The brachiopod-coral assemblage allows the lower Tirekhtyakh horizon to be correlated with the 5b beds of Norway. On Mirny Creek the deposits also contain trilobites, gastropods, ostracodes and other fossils (Sokolov *et al.* 1983).

The upper Tirekhtyakh horizon corresponds to the *Climacograptus*? *extraordinarius* and *Glyptograptus*? *persculptus* Zones. The *extraordinarius* Zone, which was first established on Mirny Creek (Koren & Sobolevskaya 1979), corresponds to the index-species range. Apart from the latter, it contains *Climacograptus*? ex gr. *extraordinarius* (Sobolevskaya), *C. angustus* (Perner), *C. normalis* Lapworth and *C. mirnyensis* (Obut & Sobolevskaya). *Climacograptus* aff. *medius* Törnquist and scarce *Glyptograptus* sp. appear in the upper part of the zone.

The *persculptus* Zone was recognized as equal to the full range of the index-species and the zonal assemblage also contains *Climacograptus angustus* (Perner), *C. normalis* Lapworth, *C. mirnyensis* (Obut & Sobolevskaya) and *C. torosus* Koren & Sobolevskaya.

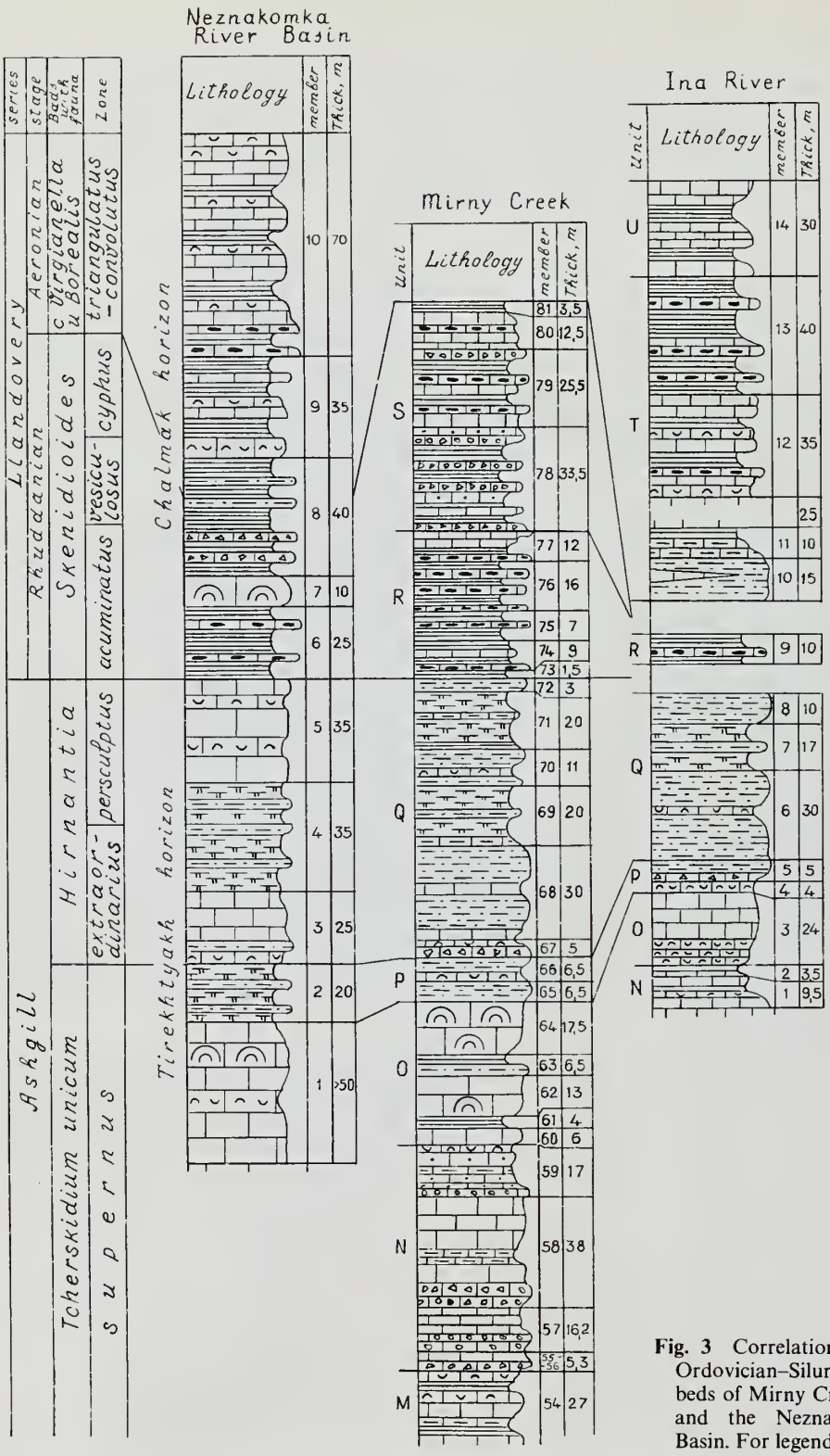

Fig. 3 Correlation chart of the Ordovician–Silurian boundary beds of Mirny Creek, Ina River and the Neznakomka River Basin. For legend see Fig. 2.

At Mirny Creek, the Khekanda and Neznakomka rivers and Mount Kharkindzha, this zone is equated with the *Hirnantia*? beds (Oradovskaya 1977). Amongst the brachiopods the most common are *Dolerorthis*? *savagei* Amsden, *Brevilamunella thebesensis* (Savage), *Rafinesquina*? *latisculptilis* (Dalman) and *Giraldibella bella* (Bergström), and the trilobites *Bumastus* (*Bumastus*) *commodus* Apollonov and *Mucronaspis kolymica* Chugaeva. *Dalmanitina olini* Temple occurs near the top of the zone.

The Chalmak horizon

In the Omulev Mountains the lower Chalmak horizon includes the Maut Formation, and the main Chalmak Formation corresponds to the horizon in the Yasachnaya Basin. On the Omulev Uplift, the Maut Formation consists of dark calcareous shales, shales and cherts containing graptolites which are interbedded with detrital and conglomerate-like limestones with a scarce neritic fauna. Coarse clastic rocks dominate the coeval deposits further south-east.

The lower part of the horizon corresponds to the *Parakidograptus acuminatus* and *Akidograptus ascensus* Zones recognized in Mirny Creek, the Ina and Khekanda rivers, and Mount Kharkindzha. The most complete graptolite assemblage was reported from Mirny Creek (Obut *et al.* 1967). As well as *P. acuminatus* and *A. ascensus*, the assemblage includes *Climacograptus rectangularis* (M'Coy), *C. transgrediens* Waern, *Paraclimacograptus sinitzini* Chalatskaya, *Diplograptus* ex gr. *modestus* Lapworth and *Glyptograptus* ex gr. *tamariscus* (Nicholson). The boundary of the zone is drawn by the appearance and disappearance of the diagnostic species.

The *acuminatus* and *ascensus* Zone corresponds to the lower *Skenidioides* beds containing *Skenidioides* cf. *scolioides* Temple, *Leptaena* aff. *aequalis* Amsden, *Eospirigerina putilla* Oradovskaya, *Zygospiraella* sp. and *Protatrypa* sp. The assemblage is similar to the brachiopod fauna from the lower Llandovery of the Northern Appalachians (Ayrton *et al.* 1969). The beds also contain trilobites such as *Acernaspis* sp., Tropidocoryphinae gen. et sp. indet. and the corals *Palaeofavosites balticus* Rukhin, and *Propora conferta* Edwards & Haime, among others.

The systemic boundary

The most complete and well known section of the Tirekhtyakh and Chalmak horizons is exposed along the Mirny Creek. A point 2·5 km from its mouth was chosen as a regional type section for the Ordovician–Silurian boundary in the north-east USSR. The systemic boundary is drawn at the base of unit 73 which is 1·5 m thick and coincides with the base of the Maut Formation (Figs 2, 3). This level corresponds to the base of the *acuminatus* and *ascensus* Zone which in the section studied is substantiated by the appearance of representatives of such typically Silurian groups as *Diplograptus modestus* Lapworth and *Glyptograptus tamariscus* (Nicholson) (unit 73). The index-species *Akidograptus ascensus* Davies is known from the base of unit 74, 1·5 m above the boundary, and *Parakidograptus acuminatus* (Nicholson) occurs in the lower part of unit 75, 11 m above the boundary. Their absence from the basal layer can be attributed to the difficulty in searching for graptolites in the beds. In the section at Mount Kharkindzha, akidograptids are known from the basal beds of the Maut Formation associated with other typical diplograptids.

The principal criteria for establishing the boundary on a regional scale are distinct changes in the lithological composition of the deposits as well as the change in the assemblages of graptolites (*persculptus/acuminatus* and *ascensus*), brachiopods (*Hirnantia*?/*Skenidioides*) and trilobites. Graptolites allow interregional and global correlations of the level.

The section at Mirny Creek is well exposed and shows a continuous succession of uniformly dipping deposits containing diverse fossils. Its major advantage is bed-by-bed graptolite control within the range of the *Dalmanitina–Hirnantia* assemblage and the presence of shelly fauna (the *Skenidiodes* beds) from the base of the *acuminatus* and *ascensus* Zones.

Abundant graptolites, brachiopods and corals and rare trilobites, ostracodes and conodonts are known from the Ordovician–Silurian boundary beds in the north-east USSR. All faunal groups except ostracodes and conodonts have been monographically described in different

publications (Sokolov *et al.*, 1983; Nikolaev *et al.*, 1977; Nikolaev & Sapelnikov 1969; Obut *et al.* 1967; Opornii razrez (Anon.) 1974; Oradovskaya 1963; Polevoi atlas (Anon.) 1968; Polevoi atlas (Anon.) 1975; Preobrazhensky 1966 and Sobolevskaya 1970, 1974).

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